HYDROSTATIC TRANSMISSION BYPASS LATCH

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. Patent Application No. 10/082,750, filed February 25, 2002, which is a division of U.S. Patent Application No. 09/637,304, filed August 11, 2000, now U.S. Patent No. 6,374,604 and, therefore, claims the earlier filing date under 35 U.S.C. 120. Both of these applications are incorporated herein by reference in their entirety.

FIELD OF THE INVENTION

The present invention relates generally to hydrostatic transmissions ("HST") and transaxles including hydrostatic transmissions, and in particular to a bypass system for such transmissions. Specific exemplary embodiments discussed herein relate to riding lawn mowers and similar small tractors.

BACKGROUND OF THE INVENTION

The description of art in this section is not intended to constitute an admission that any patent, publication or other information referred to herein is "prior art" with respect to this invention, unless specifically designated as such.

Riding lawn mowers and small tractors **10** of the type discussed herein and depicted in Figs. 1A and 1B generally use an engine having a vertical output shaft **12** that is connected to the transaxle **14** via a conventional belt and pulley system **16**. A standard HST for such a transaxle includes a hydraulic pump that is driven by the engine output shaft **12**, and a hydraulic motor, both of which are usually mounted on a center section. Rotation of the pump by an input shaft creates an axial motion for the pump pistons. The oil pressure created by this axial motion is channeled via porting to

the hydraulic motor, where it is received by the motor pistons. The axial motion of these pistons against a thrust bearing causes the motor to rotate. The hydraulic motor in turn has an output shaft that drives the vehicle axles through differential gearing. For additional background, the reader is referred to U.S. Patent No. 5,201,692, ("the '692 patent") issued to Johnson et al., and incorporated herein by reference in its entirety.

A problem with the typical HST arrangement is that a "neutral gear" does not exist, as it is merely a point where the hydraulic pressure in the pump goes to zero.

However, at this point the oil remains in the transmission, preventing the vehicle from being freely rolled. The present invention is an improvement over prior art methods used to place a transaxle into neutral gear and enable movement of the tractor without the motor running or, more generally, without the transmission being engaged.

Prior art has solved the problem by diverting the oil through a hydraulic valve from the pressure side to the vacuum side of the HST center section. The problem with such a design is that the hydraulic valve allows for the movement of only a limited amount of oil due to inherent design limitations, such as the diameter of the hydraulic valve through which the oil is diverted. Machining such a valve also requires precise tolerances, thus increasing the manufacturing costs of the unit.

The '692 patent solves this neutral gear problem by providing a mechanism whereby the motor block is mechanically lifted from its running surface. This mechanism allows the oil to bypass the vacuum-pressure (hydraulic) circuit and to exit the case completely. This mechanism operates to enable the vehicle to free-wheel more easily than is possible with prior art hydraulic valve methods.

Fig. 1C (which is similar to Fig. 2 of the '692 patent) is a section view through the transaxle **14**. To activate the bypass feature disclosed in the '692 patent, a bypass arm **18** is manipulated by the user to rotate a bypass actuator **20**. The bypass actuator **20** includes a rod **22** which is shaped at its base **24** so that rotation of the rod **22** forces a bypass plate **26** to press against the base of the motor **29**, thereby breaking its seal to the motor running surface (See Figs 2 and 5 of the '692 patent). It will be apparent to those of skill in the art that a pin or multiple pins, or other mechanical means may be used to lift the motor block. These mechanical lifting mechanisms allow the oil to flow between the motor and the transmission cavity.

A bypass rod **28** is connected to the bypass arm **18** to facilitate manipulation of the bypass arm **18**. Fig. 1D shows the bypass rod **28** in an unlocked position. The prior art means for activating the bypass mechanism includes pulling the bypass rod **28** through the tractor hitch plate **30** and securing it in place with a weldment (or cross pin) **32**. To secure the bypass rod **28** in the hitch plate **30**, the hitch plate **30** must include a relatively complex stamp out, e.g., a keyhole **34**. See Fig. 1F which shows the bypass rod **28** extending through the keyhole **34** of the hitch plate **30**. Perhaps more troublesome is the requirement to have tight tolerances for setting the cross pin **32** relative to the hitch plate **30** and, the keyhole **34**. This tolerance requirement is especially frustrating because manufacturing tolerances involving the hitch plate **30** and the vehicle frame are much looser.

While the present invention relates to hydrostatic transaxles and transmissions generally, it will be better understood within the discussion of exemplary embodiments directed toward riding lawnmowers and similar small tractors.

SUMMARY OF THE INVENTION

A primary object of the present invention is directed toward a bypass system, and in particular, a bypass latch, for a hydrostatic transaxle or transmission. A hydrostatic transaxle according to one embodiment of the present invention comprises a casing including a hydrostatic transmission located in the casing. The transmission comprises a motor on a motor running surface and a pump connected to the motor via a hydraulic circuit. A bypass actuator, in a preferred embodiment, is rotatably positioned to lift the motor from the motor running surface when the actuator is rotated such that hydraulic fluid flows out of the motor (a part of the hydraulic circuit). Alternatively, other components can be shifted to allow fluid to flow out of the hydraulic circuit. A bypass arm is preferably positioned external to the casing (though need not be) and affixed to the bypass actuator' and rotatable therewith. A latch arm that is rotatable about an axis parallel to an axis about which the bypass actuator rotates is adapted to releasably engage the bypass arm. The latch arm is coupled with a brake rod such that operation of the brake rod disengages the latch arm from the bypass arm, whereby the bypass actuator is disengaged and the transmission is thereby engaged.

Accordingly, an embodiment of the invention is directed toward a bypass 15 assembly comprising a latch arm having a latching end for releasably engaging the bypass arm and a brake end coupled with a brake rod. A returning spring, preferably an extension spring, is connected to the latch arm to apply a returning force to bias the latch arm toward an at-rest position. In a preferred embodiment the at-rest position is the position where the brake end of the latch arm abuts, or is stopped against, a brake arm. A second spring, preferably a compression spring, cooperating with the brake rod is used to apply a braking force to the brake arm when the brake rod is actuated. In a

preferred embodiment, the compression spring transmits a force to the braking end of the latch arm prior to transmitting a braking force to the wheels or axles of the tractor. A slidable member adapted to control the timing of the force may be positioned on the brake rod.

One advantage of the design is that it is integral with the transmission. One method of integrating a bypass latch with a hydrostatic transmission according to the present invention comprises placing the hydrostatic transmission in a casing and connecting a bypass actuator to the transmission. This allows the transmission to roll more freely when the bypass actuator is engaged than when the bypass actuator is disengaged. A bypass arm positioned external to the casing is connected to operate the bypass actuator. A latch arm adapted to releasably engage the bypass arm is positioned external to the casing as well. The method of integrating further includes linking the latching arm to a brake rod such that operation of the brake rod causes the latching arm to release the bypass arm, whereby the bypass actuator is disengaged.

By integrating the design, the manufacturer could provide a means to actuate the bypass that is less expensive than the prior art. The current means of activation involves a bent wire form with a weldment (or cross pin). A straight wire form, rod, or stamping could be used with the proposed invention thereby reducing tolerance requirements and costs.

Another advantage of the invention is that it can be deactivated by the pressing of the brake pedal. Many vehicles require the operator to press the brake pedal prior to starting the tractor. The present invention, which deactivates the bypass actuator when the brake pedal is applied, insures that the transmission is ready for operation. This is

particular useful when the user has perhaps forgotten that the bypass has been left "on," i.e. the transmission is disengaged.

Other objects and advantages in accordance with the present invention will be apparent to those of skill in the art from the teachings disclosed herein.

BRIEF DESCRIPTION OF THE DRAWINGS

In the interest of enabling one of skill in the art to practice the invention, exemplary embodiments are shown and described. For clarity, details apparent to those of skill in the art without undue experimentation are generally omitted from the drawings and description.

Fig. 1A depicts a plan view of a typical lawn tractor.

Fig. 1B shows a lawn tractor similar to that of Fig. 1A with a cutout to show a transaxle connected to an engine output via a belt system.

Fig. 1C is a section view through a prior art transaxle showing a bypass actuator.

Fig. 1D is an enlarged view of Fig. 1B showing a prior art design for manipulating and locking a bypass arm.

Fig. 1E shows the bypass arm of Fig. 1D secured in an engaged position via a cross pin on the bypass rod.

Fig 1F shows the bypass rod of Fig. 1E extending through a keyhole stamp out in the tractor hitch plate.

Fig. 2 shows a bypass latch according to one embodiment of the present invention.

Fig. 3 depicts an enlarged view the transaxle of Fig. 2, showing the bypass arm disengaged i.e., transmission engaged.

Fig. 4 is similar to Fig. 3 but with the bypass arm in the "on" or latched position.

Fig. 5 shows a rear view of a vehicle employing the present invention such that only a circular stamp out is needed in the hitch plate to allow the bypass rod to pass through.

Fig. 6 shows a cutout view of Fig. 5 to more clearly show the transaxle.

Fig. 7 shows a top view of a transmission similar to that show in Fig. 2, but with the bypass rod extending in the opposite direction.

Fig. 8 is a side view of the transmission shown in Fig. 7 showing the bypass in the "off" position.

Fig. 9 is a top view of the transmission shown in Fig. 7 with the bypass rod is being pushed to activate the bypass actuator and the bypass arm is starting to engage the latch arm.

Fig. 10 shows a top view of the transmission shown in Fig. 9 with the bypass arm latched in the "on" position, thereby disengaging the transmission.

Fig. 11 shows a top view of the transmission of Fig. 7 with the bypass arm being unlatched.

Fig. 12 is a side view of the transmission shown in Fig. 11 but with the bypass fully disengaged and the brake arm activated.

Fig. 13 is a perspective view of the bypass latch system according to the present invention, showing the bypass in the on position.

Fig. 14 is an isometric view of an alternative bypass latch using a different latch arm with a latching end having a tab generally perpendicular to the axis of the arm.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

The present invention is discussed in relation to lawn tractors, however, other uses will be apparent from the teachings disclosed herein. The present invention will be

better understood from the following detailed description of exemplary embodiments with reference to the attached drawings, wherein like reference numerals and characters refer to like parts, and by reference to the following claims.

Fig. 2 depicts a transaxle **14** with bypass latch **36** shown installed in the tractor **10**. The bypass arm is shown in the "off' position or the disengaged position. Some vehicles may have the transaxle **14** (or more generally the transmission) rotated 180 degrees from what is shown in Fig. 2. If the transaxle is rotated, then the bypass rod **28** may extend forward, rather than rearward as shown. The bypass rod **28** may also be rotated relative to the transaxle **14** to provide access to the bypass actuator from another direction without changing the orientation of the transaxle **14**. Thus, a design wherein the bypass rod **28** extends out the back of vehicle **10** is only one of many options for providing customer access. For example, in an embodiment wherein the bypass rod **28** extends to one of the sides, the attachment point of the bypass arm **18** need only be rotated 90 degrees to provide the desired coupling between the bypass actuator **20** and the bypass rod **28**. Other mechanisms to attain the desired rotary motion will be apparent to those of skill in the art.

Fig. 3 depicts an enlarged view of Fig. 2, showing a hydrostatic transaxle according to one embodiment of the present invention. The transaxle **14** comprises a casing **38** including a hydrostatic transmission located in the casing (the transmission is not shown in Fig. 3). Reference should be made to the '692 patent for additional detail regarding the general background of the invention. The transmission comprises a motor on a motor running surface and a pump connected to the motor via a hydraulic circuit. A bypass actuator **20** is rotatably positioned to lift a transmission component

when the actuator **20** is rotated such that hydraulic fluid flows out of the hydraulic circuit. In a preferred embodiment the motor **29** is lifted from the motor running surface when the bypass actuator **20** is rotated. A bypass arm **18** is preferably positioned external to the casing **38** and affixed to the bypass actuator **20** and rotatable therewith. A latch arm **40**, that is rotatable about an axis **42** (See Fig. 13) which is parallel to an axis **44** about which the bypass actuator **20** rotates, is adapted to releasably engage the bypass arm **18**. The latch arm **40** is coupled with a brake rod **46** such that operation of the brake rod **46** disengages the latch arm **40** from the bypass arm **18**, whereby the bypass actuator **20** is disengaged and the transmission is thereby engaged as the motor (or other transmission component) reseats itself.

Accordingly, an embodiment of the invention is directed toward a bypass assembly **48** such as shown in Fig. 13. The assembly **48** comprises a latch arm **40** rotatable about an axis **42** parallel to an axis **44** about which the bypass arm **18** rotates. The latch arm **40** comprises a latching end **50** for releasably engaging the bypass arm **18** and a brake end **52** coupled with a brake rod **46**. In a preferred embodiment, the brake end **52** is slidably coupled with the brake end **46**, but other means for movably coupling the two will suffice. A return spring **54**, preferably an extension spring, is connected to the latch arm **40** to apply a returning force to bias the latch arm **40** toward an at-rest position (See Figs. 3 and 7). In a preferred embodiment, the at-rest position is the position where the brake end **52** of the latch arm **40** abuts, or is stopped against, a brake arm **56**; intervening structure, such as spacers is acceptable. The brake end **52** need not directly rest against the brake arm **56**. A compression spring **58** cooperating with the brake rod **46** is used to apply a braking force to the brake arm **56** when the

brake rod **46** is actuated. In a preferred embodiment, the compression spring **58** transmits a force to the braking end **52** of the latch arm **40** (via a bushing **60** positioned on the brake rod **46**) prior to the compression spring **58** transmitting a braking force, via the brake arm **56**, to the wheels **59** or axles of the tractor **10**.

More generally, the bushing **60** may be a slidable member adapted to apply the brake force (from the brake rod **46**) to the latch arm **40** before the brake arm **56** is activated. Preferably the slidable member is positioned on the brake rod **46** between the compression spring **58** and the brake arm **56**. In a preferred embodiment, the bushing **60** and the brake arm **56** are designed such that an end of the bushing will pass through an opening **62** in the brake arm **56**, but an opposing end of the bushing **60** will not pass through the opening **62**.

In Figs. 3 and 7, the latch arm **40** is positioned against the brake arm **56** and the spacer **60** (bushing) as well, i.e. the latch arm **40** is not directly against the brake arm **56**. The bypass rod **28** is positioned rearward in Fig. 3 and forward in Fig. 7. The vehicle will not roll easily in this condition, where the transmission is engaged, without engine input because of back driving the gears, the pump, the pulleys, etc. To engage the bypass actuator **20**, in the orientation shown in Fig. 3, the user pulls the bypass rod **28.**

Fig. 4 shows the same transaxle **14** as Fig. 3 but with the bypass **20** latched in the "on" position. Since the bypass is engaged, the vehicle may be rolled relatively easier even though there is no engine input. Fig. 5 shows a rear view of the vehicle **10** showing the hitch plate **30**. The stamp out through which the bypass rod **28** extends is not visible behind the end of the bypass rod **28**. Fig. 6 is a cutout of Fig. 5 to more

clearly show the transaxle **14**. The mower deck **11** is shown roughly aligned with the wheel axles. Note that the preferred stamp out in the present invention is circular. The present invention avoids the need for a keyhole stamp out and for a cross pin on the bypass rod **28** to secure the bypass actuator **20** in an engaged position.

Fig. 7 shows a top view of a transmission similar to the transaxle of Fig. 3 (with the axles removed), but with the bypass rod **28** extending in the opposite direction, i.e., it is rotated 180° in a plane normal to the axis **44** of the actuator **20**. Accordingly, the bypass rod **28** would be pushed in toward the case **38** of transmission to activate the bypass actuator **20.** Thus a rider could reach the rod **28** from the tractor seat **64** (See, e.g., Fig. 1A). While activation of the actuator **20** has been described in relation to pushing and pulling the bypass rod **28** relative to the casing **38**, this is only for convenience. Other methods for manipulating the bypass arm **18** are within the spirit of the invention and will be understood by those of skill in the art. Furthermore, the latching assembly **48** may be readily adapted to operate with other chosen methods of bypass-arm manipulation so as to couple operation of the brake to the latch. The bypass arm **18** is in the disengaged or "off' position and the latch arm **40** is at an at-rest position against the brake arm **56** and directly against the spacer **60**.

Fig. 8 is a side view of the transmission shown in Fig. 7; the bypass is in the "off" position. The compression spring **58** is not compressed and the brake arm **56** is not engaged.

Fig. 9 is a top view of the transmission shown in Fig. 7. The bypass rod **28** is shown being pushed to activate the bypass actuator **20**. The bypass arm **18** is starting to engage the latch arm **40**. The extension spring **54** is being stretched and exerting a

force on the latch arm **40** brake end **52** to bias the latch arm **40** toward the at-rest position. Spring **54** also forces the latching end **50** in the opposite direction as that of the brake end **52** since the latch arm **40** rotates about axis **42** (through bolt **66**) which is positioned between the brake end **52** and the latching end **50**.

Fig. 10 shows the bypass arm **18** latched in the "on" position, thereby disengaging the transmission so the tractor rolls relatively more freely. The extension spring **54** exerts a force to maintain the latching end **50** of the latching arm **40** in engagement with the bypass arm **18**. When the brake rod **46** is being actuated, the force transmitted to the latching arm **40** (via the compression spring **58**) will overcome the force from the extension spring **54** and rotate the latch arm **40** out of engagement with the bypass arm **18**. The springs in the hydraulic motor act to return the bypass actuator **20**, and the bypass arm **18**, to a disengaged position.

Fig. 11 shows the bypass arm **18** being unlatched. The brake rod **46** is activated (via operator foot pedal typically) moving the compression spring **58** in contact with the bushing **60**. As the brake rod **46** and compression spring **58** move further forward, the bushing **60** slides through the brake arm **56** and makes contact with the latch arm **40** at its brake end **52**. As the bushing **60** (or spacer) applies a force to the latch arm **40**, the latch arm **40** starts to disengage from the bypass arm **18**. The brake arm **56** has not yet rotated, i.e., the compression spring **58** has not yet applied a force (or, a sufficient force) to the brake arm **56** when the latch arm **40** disengages the bypass arm **18**. As the compression spring **58** on the brake rod **46** is further compressed (or pulled further forward by the brake rod **46**), the brake arm **56** begins to be activated. Activating the brake arm **56** applies a braking force to the wheels **59** (or axles depending on the

system). Thus, a system that utilizes dynamic braking (via the hydrostatic transmission) prior to conventional wheel/axle braking is achieved. By removing or otherwise adapting the bushing **60** or the latch arm **40** or both, the latch arm **40** can be made to disengage the bypass arm **18** contemporaneously with the onset of the brake arm **56** activation. The latching assembly can also be made to disengage the bypass arm **18** after activation of the brake arm **56** or, as previously discussed, before activation of the brake arm **56**.

Fig. 12 is a side view of the transmission shown in Fig. 11 but with the bypass arm (not shown) fully disengaged, the compression spring **58** fully compressed and the brake arm **56** activated. By comparison, Fig. 8 is a similar view prior to the brake arm **56** being activated.

Fig. 13 is a view of a bypass latch assembly 48 according to an embodiment of the present invention showing the bypass mechanism 48 in the engaged position, so that rod 22 is rotated to force plate 26 towards the cylinder block of motor 29, thus lifting motor 29 off the motor running surface 51 of center section 53. Fig. 14 is an isometric view of a bypass assembly **48** with an alternative bypass latch arm **40'** having a different latching end **50'** from that shown in Fig. 13. The latching end **50'** has a tab **68** extending generally perpendicular to the axis of the arm **40'** (i.e., the tab **68** extends generally parallel to axis **42**). The tab **68** need not extend perpendicular to the axis of the latch arm **40** but may be at a predetermined angle measured relative to the axis of the latch arm **40** or measured relative to an axis parallel to axis **42**. The tab **68** allows the manufacturer to use looser manufacturing tolerances while achieving the desired latching capability. For example, the bypass arm **18** may be allowed out of plane

movement, rather than being rigidly held to a motion in a common plane with the latching arm **40**. Another alternative comprises adapting the latching end of the bypass arm **18** to latchingly engage the latching arm **40** even though both arms move out of plane.

While the invention has been particularly shown and described with reference to particular embodiments thereof, it will be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention. The scope of the claimed invention is intended to be defined by following claims as they would be understood by one of ordinary skill in the art with appropriate reference to the specification, including the drawings, as warranted.